

CLAIMS

The invention claimed is:

1. A method of forming a capacitor, comprising:

forming a conductive metal first electrode layer over a substrate, the conductive metal being oxidizable to a higher degree at and above an oxidation temperature as compared to any degree of oxidation below the oxidation temperature;

feeding at least one oxygen containing vapor precursor to the conductive metal first electrode layer below the oxidation temperature under conditions effective to form a first portion oxide material of a capacitor dielectric region over the conductive metal first electrode layer;

feeding at least one oxygen containing vapor precursor over the first portion at a temperature above the oxidation temperature effective to form a second portion oxide material of the capacitor dielectric region over the first portion, the oxide material of the first portion and the oxide material of the second portion being common in chemical composition; and

forming a conductive second electrode layer over the second portion oxide material of the capacitor dielectric region.

2. The method of claim 1 wherein the first and second portions are formed from a common vapor precursor.

3. The method of claim 1 wherein the first and second portions are formed from different precursors.

4. The method of claim 1 wherein the first and second portions are formed by chemical vapor deposition.

5. The method of claim 1 wherein the first and second portions are formed by chemical vapor deposition using at least one common vapor precursor.

6. The method of claim 1 wherein the first and second portions are formed by chemical vapor deposition respectively comprising feeding multiple vapor precursors simultaneously to the substrate.

7. The method of claim 1 wherein the first and second portions are formed by chemical vapor deposition respectively comprising feeding common multiple vapor precursors simultaneously to the substrate.

8. The method of claim 1 wherein the first and second portions are formed by atomic layer deposition.

9. The method of claim 1 wherein the first portion is formed on the conductive metal first electrode layer.

10. The method of claim 1 wherein the second portion is formed on the first portion.

11. The method of claim 1 wherein the first portion is formed on the conductive metal first electrode layer, and the second portion is formed on the first portion.

12. The method of claim 1 wherein the conductive metal comprises a metal nitride.

13. The method of claim 1 wherein the first portion is formed to a thickness which is less than that of the second portion.

14. The method of claim 1 wherein the first portion is formed to a thickness which is no greater than one-third that of the second portion.

15. The method of claim 1 wherein the first portion is formed to a thickness which is no greater than one-fifth that of the second portion.

16. The method of claim 1 wherein the oxide material comprises aluminum oxide.

17. The method of claim 1 wherein the oxide material consists essentially of aluminum oxide, and an entirety of the capacitor dielectric region intermediate the first and second electrode layers consists essentially of aluminum oxide.

18. The method of claim 1 wherein the first portion oxide material is formed without any measurable oxidation occurring of the metal first electrode layer.

19. The method of claim 1 wherein the second portion oxide material and the first portion oxide material are formed using the same pressure and same one or more precursors.

20. The method of claim 1 wherein the second portion oxide material is formed using identical conditions under which the first portion oxide material is formed but for different temperature.

21. The method of claim 1 wherein the first and second portions are formed in a common deposition chamber without removing the substrate from such chamber intermediate formation of the first and second portions.

22. The method of claim 1 wherein the precursor flowing during formation of the second portion oxide material is at a temperature which is at least 25°C higher than during formation of the first portion oxide material.

23. The method of claim 1 wherein the precursor flowing during formation of the second portion oxide material is at a temperature which is at least 50°C higher than during formation of the first portion oxide material.

24. The method of claim 1 wherein the precursor flowing during formation of the second portion oxide material is at a temperature which is at least 100°C higher than during formation of the first portion oxide material.

25. A method of forming a capacitor, comprising:

forming a conductive metal first electrode layer over a substrate, the conductive metal being oxidizable to a higher degree in the presence of an oxygen containing material at and above an oxidation temperature as compared to any degree of oxidation below the oxidation temperature;

feeding the oxygen containing material to the conductive metal first electrode layer below the oxidation temperature under conditions effective to form a first portion oxide material of a capacitor dielectric region over the conductive metal first electrode layer;

feeding the oxygen containing material over the first portion at a temperature above the oxidation temperature effective to form a second portion oxide material of the capacitor dielectric region over the first portion, the oxide material of the first portion and the oxide material of the second portion being common in chemical composition; and

forming a conductive second electrode layer over the second portion oxide material of the capacitor dielectric region

26. The method of claim 25 wherein the first and second portions are formed by atomic layer deposition.

27. The method of claim 25 wherein the first portion is formed on the conductive metal first electrode layer.

28. The method of claim 25 wherein the second portion is formed on the first portion.

29. The method of claim 25 wherein the first portion is formed on the conductive metal first electrode layer, and the second portion is formed on the first portion.

30. The method of claim 25 wherein the conductive metal comprises a metal nitride.

31. The method of claim 25 wherein the first portion is formed to a thickness which is less than that of the second portion.

32. The method of claim 25 wherein the first portion is formed to a thickness which is no greater than one-third that of the second portion.

33. The method of claim 25 wherein the second portion oxide material is formed using identical conditions under which the first portion oxide material is formed but for different temperature.

34. The method of claim 25 wherein the second portion oxide material is formed at a temperature which is at least 25°C higher than during formation of the first portion oxide material.

35. The method of claim 25 wherein the second portion oxide material is formed at a temperature which is at least 50°C higher than during formation of the first portion oxide material.

36. The method of claim 25 wherein the second portion oxide material is formed at a temperature which is at least 100°C higher than during formation of the first portion oxide material.

37. A method of forming a capacitor, comprising:

forming a conductive metal first electrode layer over a substrate, the conductive metal first electrode layer being oxidizable to a higher degree in the presence of an oxygen containing material at and above an oxidation temperature as compared to any degree of oxidation below the oxidation temperature;

forming a capacitor dielectric region over the conductive metal first electrode layer by atomic layer deposition, the atomic layer deposition comprising forming a first portion of the capacitor dielectric region at a temperature below the oxidation temperature, and forming a second portion of the capacitor dielectric region over the first portion at a temperature above the oxidation temperature, the first portion restricting oxidation of the conductive metal first electrode layer during formation of the second portion; and

forming a conductive second electrode layer over the second portion of the capacitor dielectric region.

38. The method of claim 37 wherein the first portion is formed on the conductive metal first electrode layer.

39. The method of claim 37 wherein the second portion is formed on the first portion.

40. The method of claim 37 wherein the first portion is formed on the conductive metal first electrode layer, and the second portion is formed on the first portion.

41. The method of claim 37 wherein the conductive metal comprises a metal nitride.

42. The method of claim 37 wherein the first portion is formed to a thickness which is less than that of the second portion.

43. The method of claim 37 wherein the first portion is formed to a thickness which is no greater than one-third that of the second portion.

44. The method of claim 37 wherein the first and second portions comprise an oxide.

45. The method of claim 37 wherein the first and second portions comprise aluminum oxide.

46. The method of claim 37 wherein the second portion oxide material and the first portion oxide material are formed using the same pressure and same one or more precursors.

47. The method of claim 37 wherein the second portion oxide material is formed using identical conditions under which the first portion oxide material is formed but for different temperature.

48. The method of claim 37 wherein the second portion oxide material is formed at a temperature which is at least 25°C higher than during formation of the first portion oxide material.

49. The method of claim 37 wherein the second portion oxide material is formed at a temperature which is at least 50°C higher than during formation of the first portion oxide material.

50. The method of claim 37 wherein the second portion oxide material is formed at a temperature which is at least 100°C higher than during formation of the first portion oxide material.

51. A method of forming a capacitor comprising:

(a) forming a conductive metal first electrode layer over a substrate, the conductive metal being oxidizable to a higher degree in the presence of an oxygen containing gaseous material at and above an oxidation temperature as compared to any degree of oxidation below the oxidation temperature;

(b) chemisorbing a metal containing first species to form a first species monolayer from a gaseous first precursor onto the conductive metal first electrode layer;

(c) at a temperature below the oxidation temperature, contacting the chemisorbed first species with a second gaseous precursor comprising the oxygen containing gaseous material to react with the first species and form a dielectric metal oxide monolayer comprising the metal of the first species;

(d) chemisorbing the metal containing first species from the gaseous first precursor to form another first species monolayer over the substrate comprising the dielectric metal oxide;

(e) at a temperature above the oxidation temperature, contacting the another first species monolayer with an oxygen containing precursor to react with the first species and form another dielectric metal oxide monolayer comprising the metal of the first species, the dielectric metal oxide monolayer formed in (c) comprising a shield to oxidation of the

conductive metal first electrode layer during said contacting the another first species monolayer; and

(f) forming a conductive second electrode layer over the another dielectric metal oxide monolayer.

52. The method of claim 51 comprising repeating (b) then (c) at least once prior to commencing (d).

53. The method of claim 51 comprising repeating (b) then (c) multiple times prior to commencing (d).

54. The method of claim 51 comprising repeating (d) then (e) at least once prior to commencing (f).

55. The method of claim 51 comprising repeating (d) then (e) multiple times prior to commencing (f).

56. The method of claim 51 comprising repeating (b) then (c) multiple times prior to commencing (d), and repeating (d) then (e) multiple times prior to commencing (f).

57. The method of claim 56 wherein (d) and (e) are repeated more times than are (b) and (c).

58. The method of claim 56 wherein (d) and (e) are repeated at least five more times than are (b) and (c).

59. The method of claim 51 wherein the first gaseous precursor comprises trimethylaluminum and the dielectric metal oxide comprises aluminum oxide.

60. The method of claim 51 wherein (c) is conducted at a temperature no greater than 300°C, and (e) is conducted at a temperature of at least 325°C.

61. The method of claim 51 wherein (c) is conducted at a temperature no greater than 300°C, and (e) is conducted at a temperature of at least 425°C.

62. The method of claim 51 wherein (b) and (c) are conducted at a common temperature.

63. The method of claim 51 wherein (d) and (e) are conducted at a common temperature.

64. The method of claim 51 wherein (b) and (c) are conducted at one common temperature, and (d) and (e) are conducted at another common temperature.

65. The method of claim 51 wherein (e) is conducted at a temperature which is at least 25°C higher than during (c).

66. The method of claim 51 wherein (e) is conducted at a temperature which is at least 50°C higher than during (c).

67. The method of claim 51 wherein (e) is conducted at a temperature which is at least 100°C higher than during (c).